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Nakata et al.

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(54) **IMAGE DETECTING DEVICE AND IMAGE CAPTURING SYSTEM**

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(30) **Foreign Application Priority Data**

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Sep. 26, 2008 (JP) 2008-247039

(51) **Int. Cl.**
G01T 1/24 (2006.01)

(52) **U.S. Cl.** **250/370.15**

(58) **Field of Classification Search** 250/370.01–370.15; 378/98.8
See application file for complete search history.

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(57) **ABSTRACT**

An image detecting device includes an image detector, a temperature regulation controller, an image information output detector, and a timer, wherein the temperature regulation controller stops or relaxes the temperature regulation control operation on the image detector based on the image information output detection signal input thereto from the image information output detector, and resumes or stops relaxing the temperature regulation control operation on the image detector when the timer has measured a preset period of time after the temperature regulation control operation has been stopped or relaxed.

21 Claims, 9 Drawing Sheets

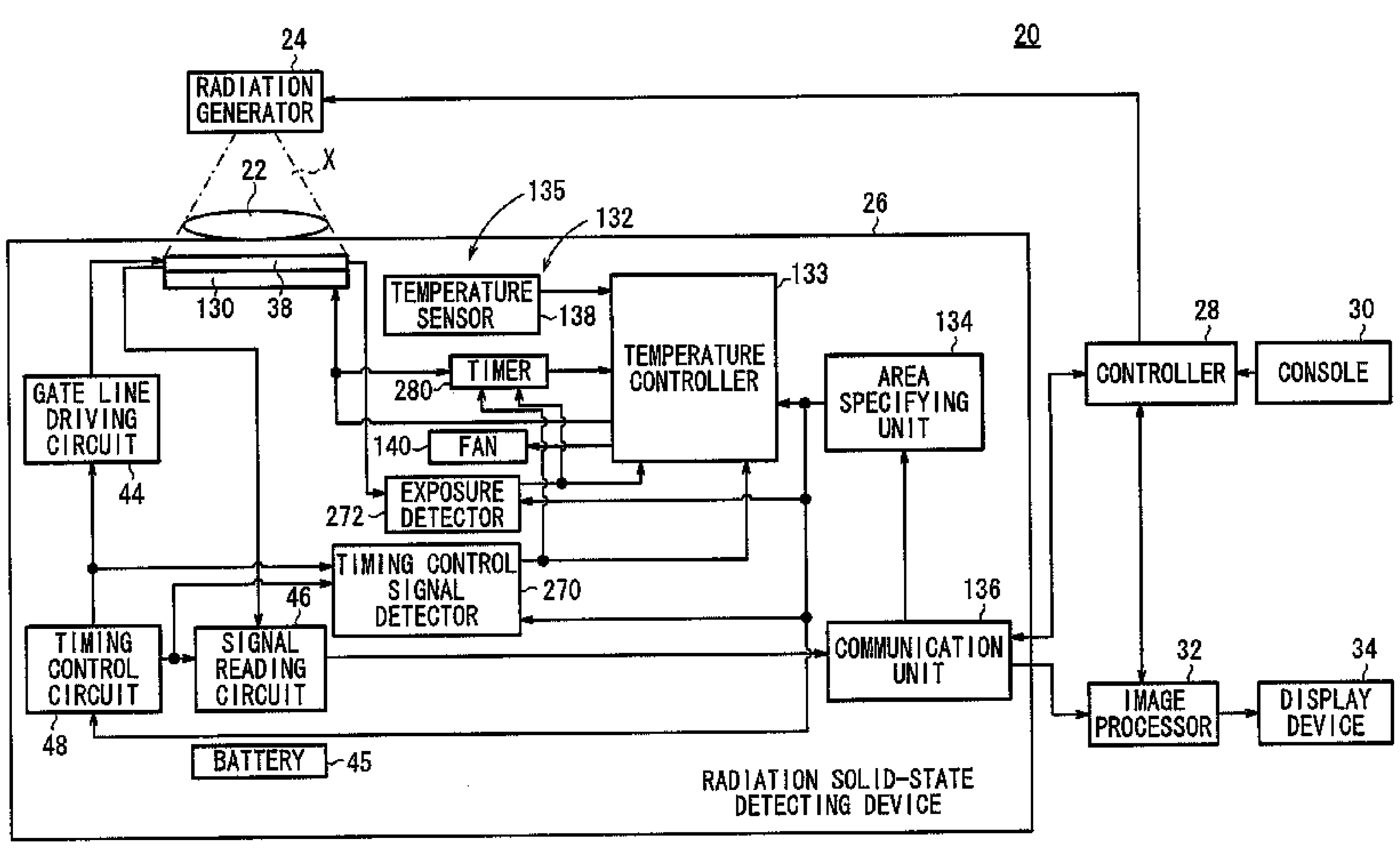


FIG. 1

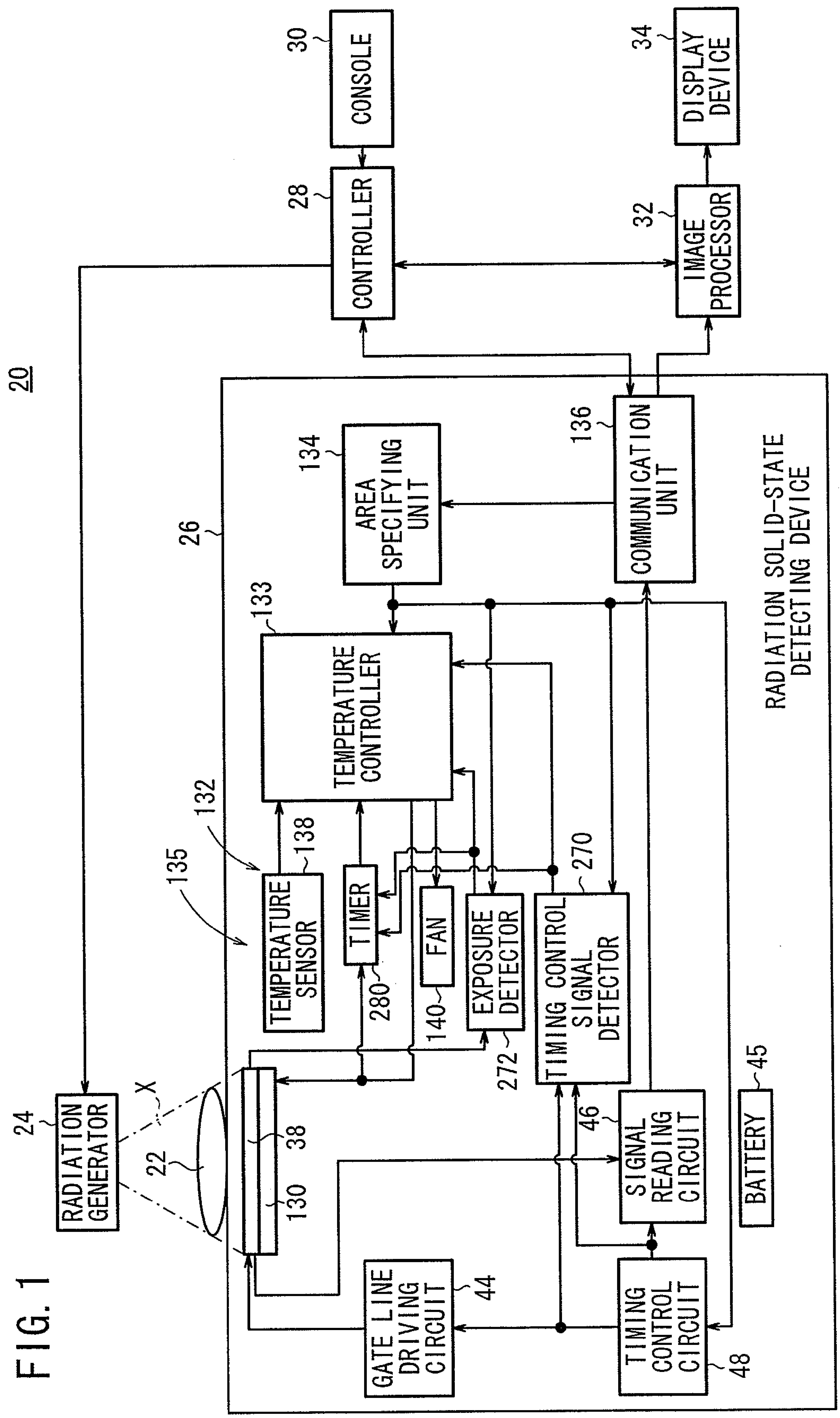
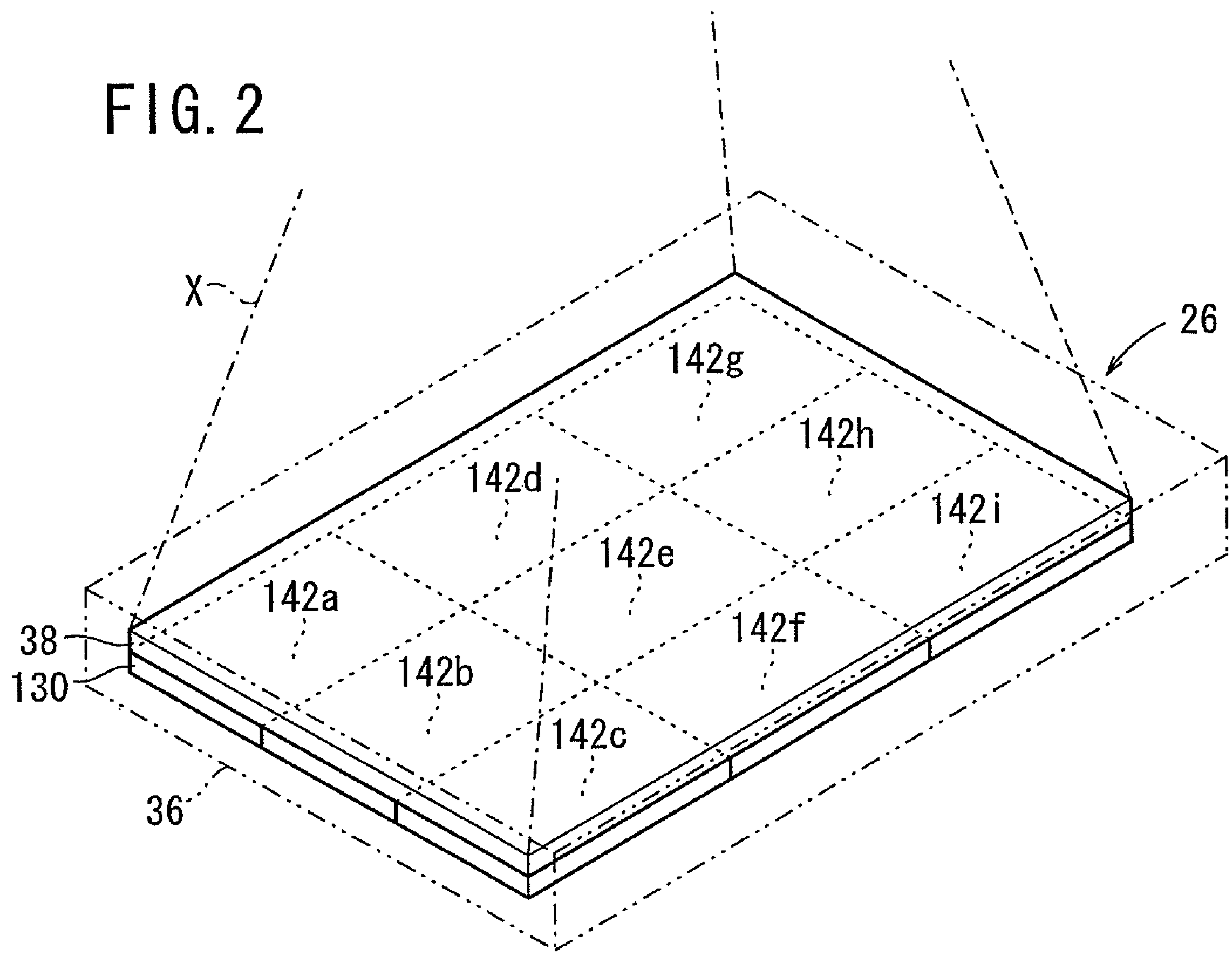

20
CONSOLE
30
CONTROLLER
28
DISPLAY DEVICE
34
IMAGE PROCESSOR
32
26
AREA SPECIFYING UNIT
134
COMMUNICATION UNIT
136
TEMPERATURE CONTROLLER
133
RADIATION SOLID-STATE DETECTING DEVICE
RADIATION GENERATOR
24
X
22
38
130
135
132
TEMPERATURE SENSOR
138
TIMER
280
FAN
140
EXPOSURE DETECTOR
272
TIMING CONTROL SIGNAL DETECTOR
270
SIGNAL READING CIRCUIT
46
BATTERY
45
GATE LINE DRIVING CIRCUIT
44
TIMING CONTROL CIRCUIT
48

FIG. 2



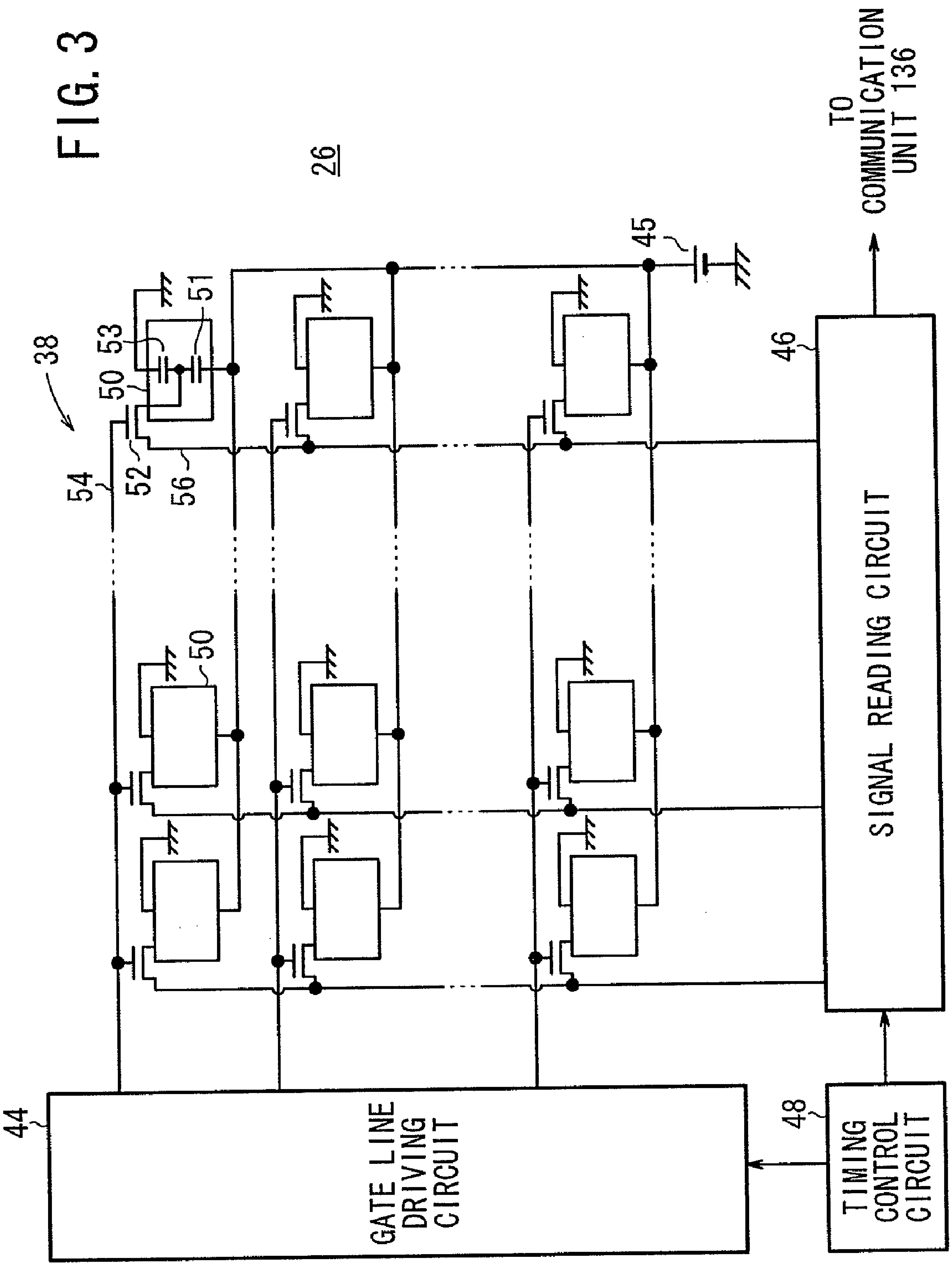

26
38
50
51
52
53
54
56
45
46
44
48
TO COMMUNICATION UNIT 136
SIGNAL READING CIRCUIT
GATE LINE DRIVING CIRCUIT
TIMING CONTROL CIRCUIT

FIG. 3

FIG. 4

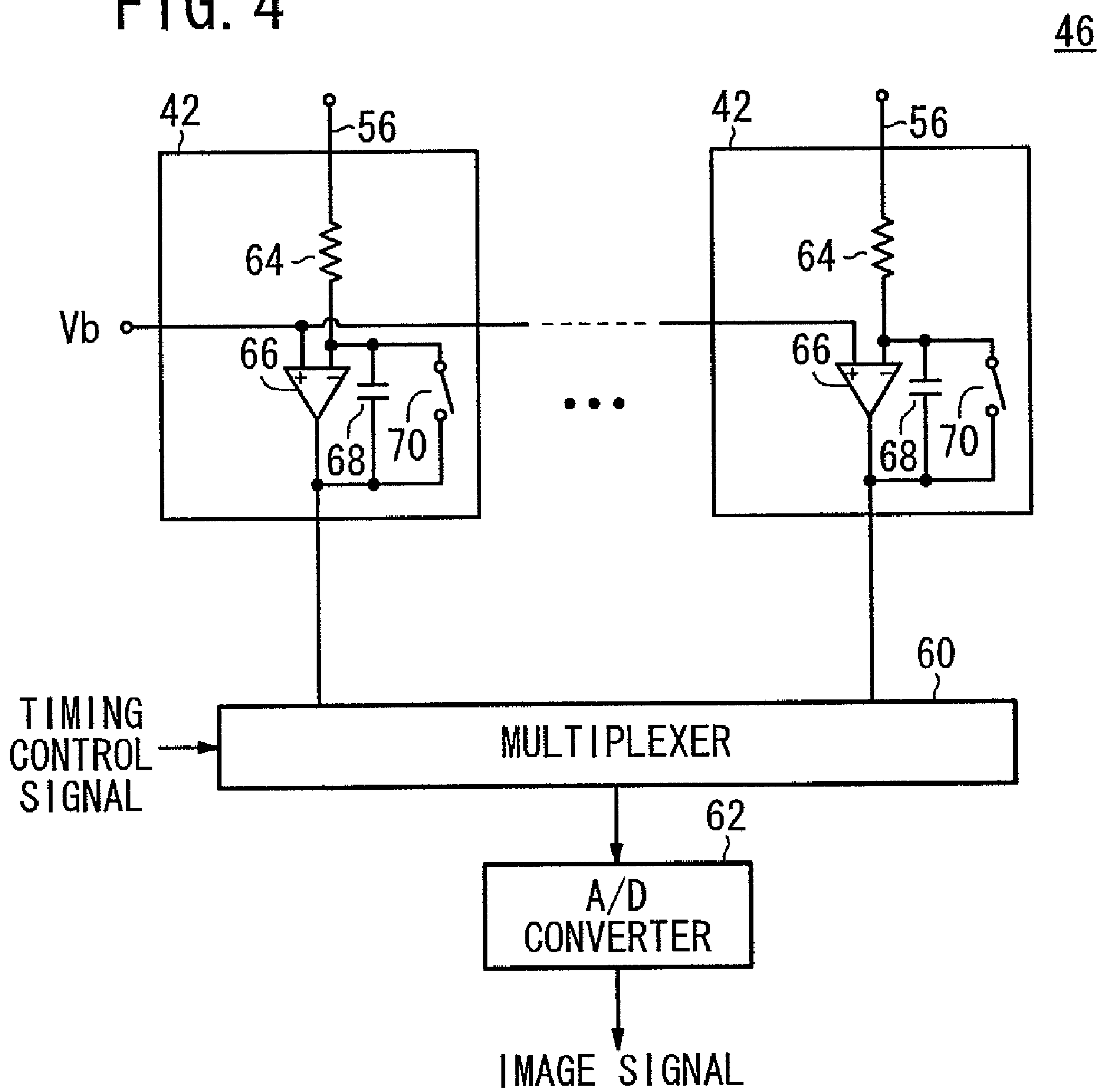

46
42
56
64
Vb
66
68
70
42
56
64
66
68
70
60
TIMING CONTROL SIGNAL
MULTIPLEXER
62
A/D CONVERTER
IMAGE SIGNAL

FIG. 5

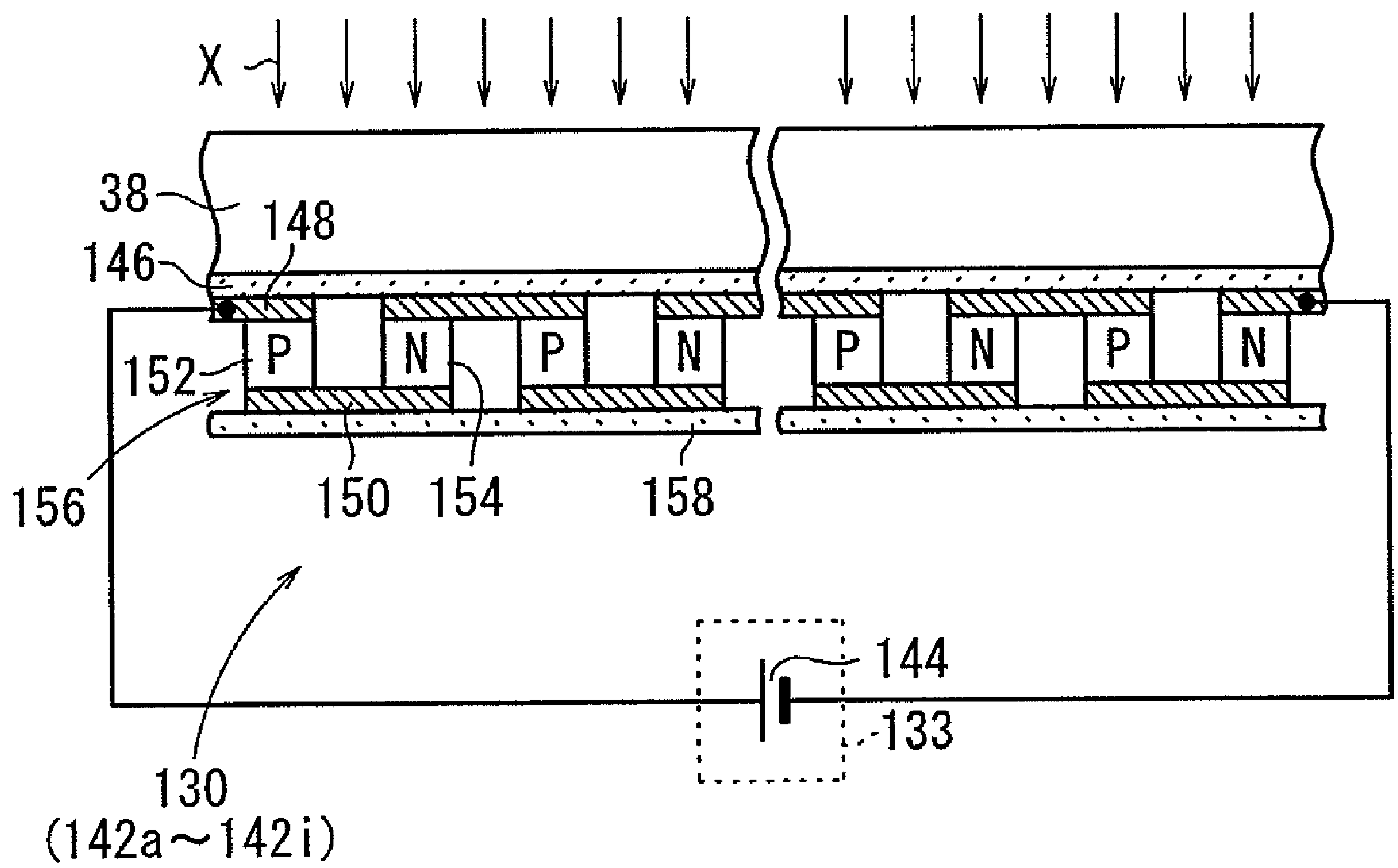


FIG. 6

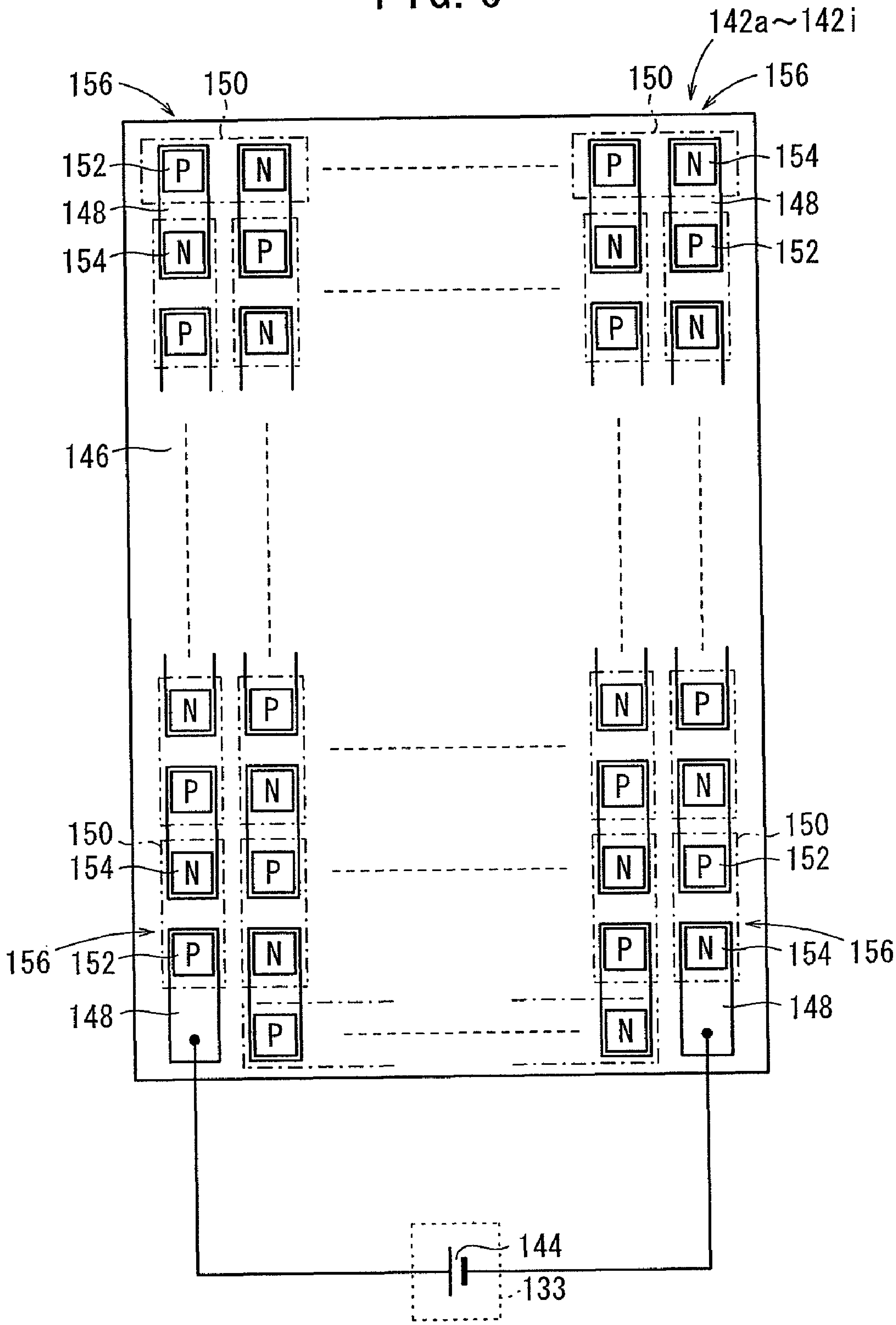
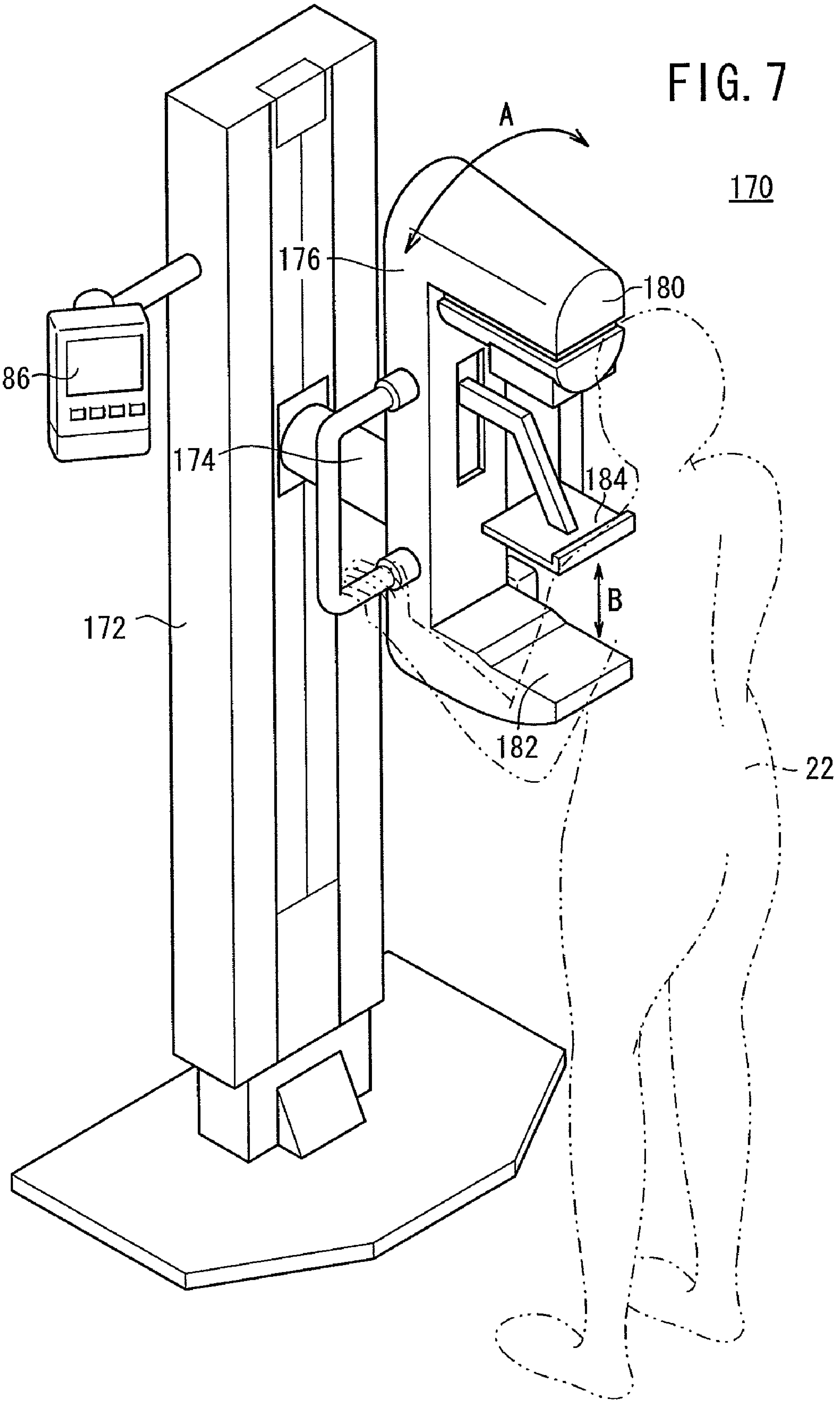

142a~142i
156
150
150
156
152
154
148
148
154
152
P
N
146
150
154
150
152
156
152
154
156
148
148
144
133

FIG. 7



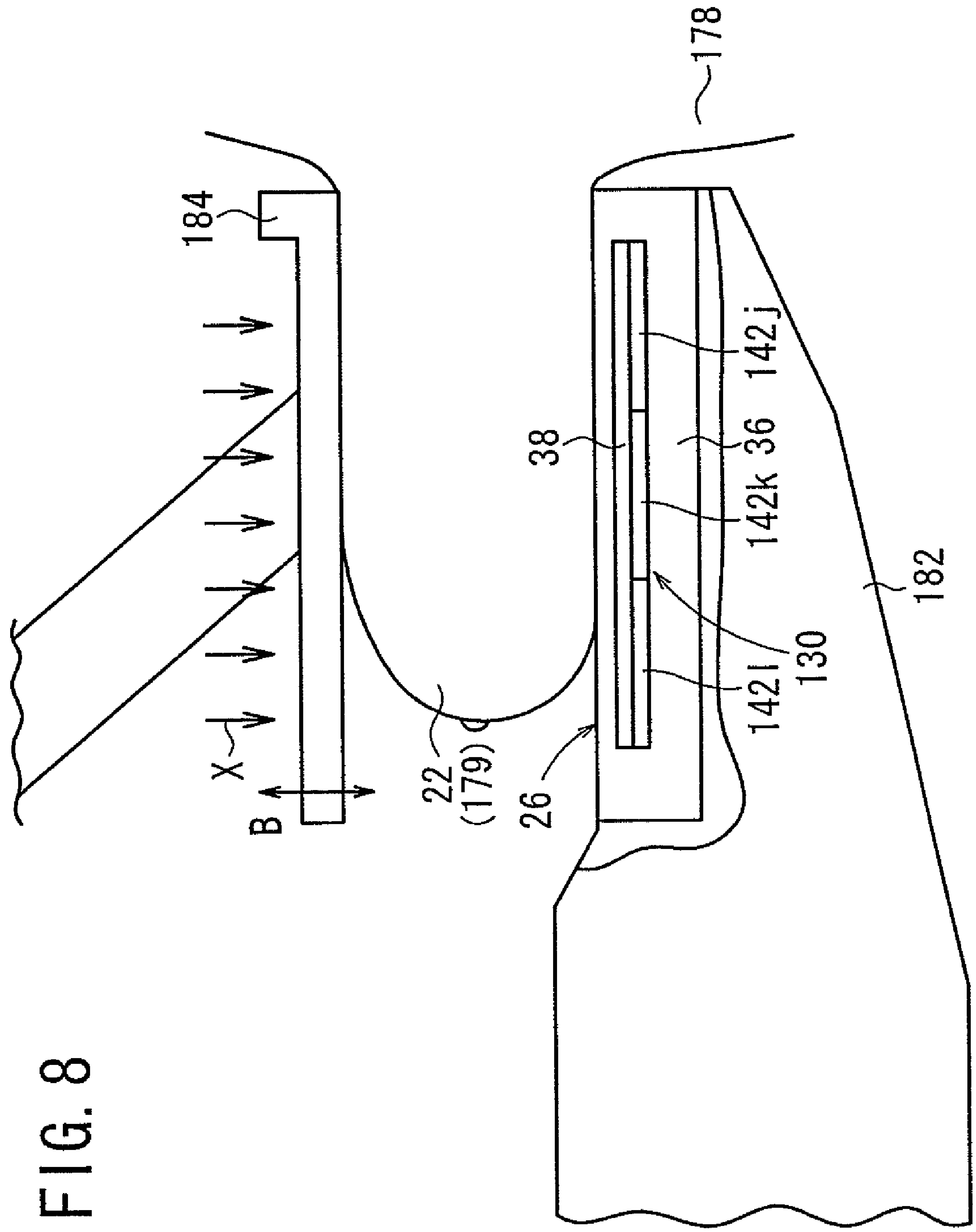


FIG. 8

FIG. 9

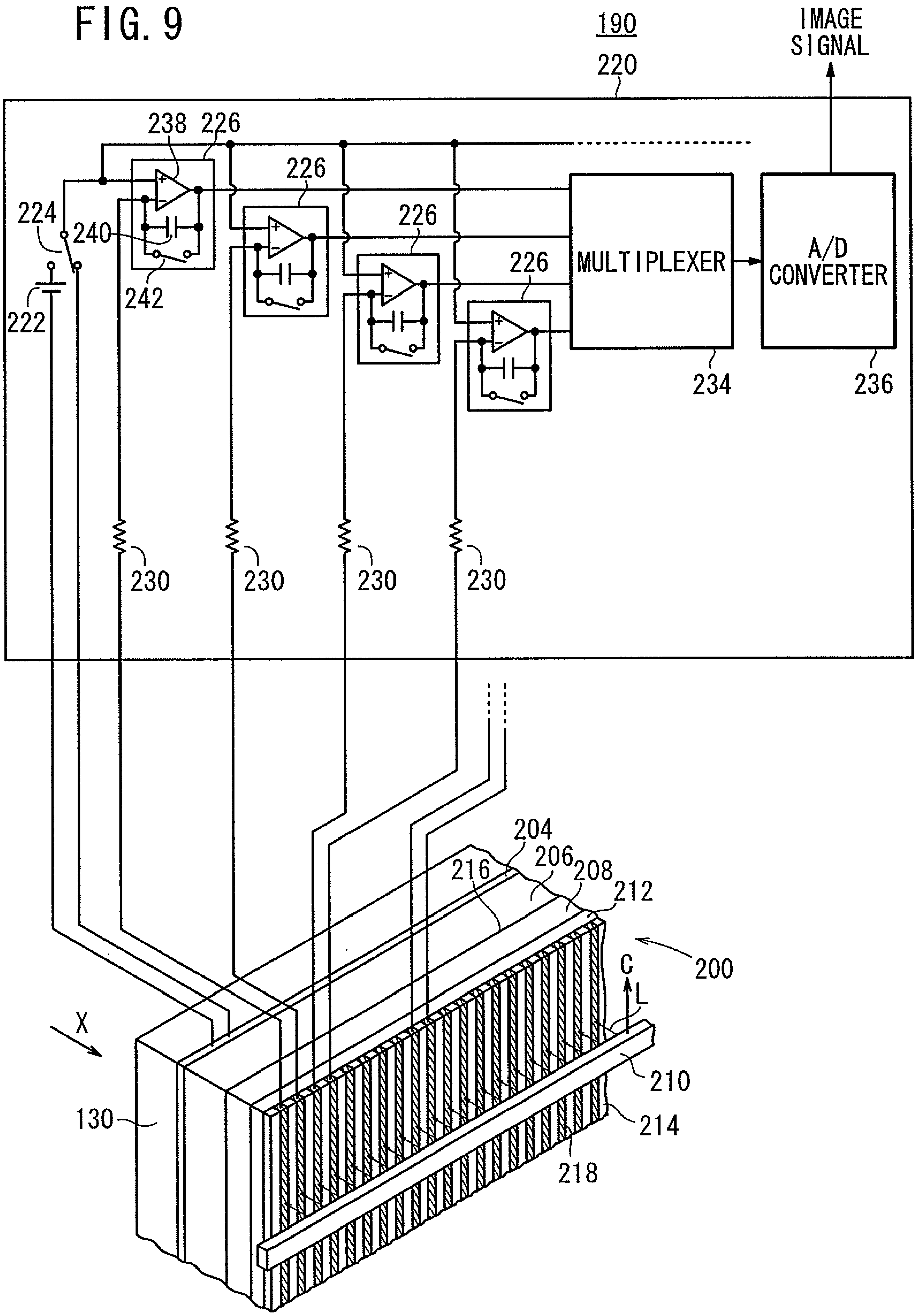

190
220
IMAGE
SIGNAL
238
226
224
240
242
222
MULTIPLEXER
A/D
CONVERTER
234
236
230
204
216
206
208
212
200
C
L
X
210
130
214
218

IMAGE DETECTING DEVICE AND IMAGE CAPTURING SYSTEM

This is a Continuation-In-Part of application Ser. No. 12/239,799 filed Sep. 28, 2008. The entire disclosure of the prior application, application number U.S. Ser. No. 12/239,799, is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image detecting device for outputting image information representative of an image recorded in a given recording area, and to an image capturing system that incorporates such an image detecting device therein.

2. Description of the Related Art

In the medical field, there have widely been used image capturing apparatuses, which apply radiation from a radiation source to a subject (a patient) and detect the radiation that has passed through the subject with an image detector, in order to acquire radiation image information of the subject.

Japanese Laid-Open Patent Publication No. 2003-014860 discloses that the temperature of a radiation detector, such as a CCD or the like, is detected by a temperature sensor and controlled to reach a predetermined temperature by way of temperature regulation, for preventing the radiation detector from suffering from dew condensation.

When an image detector such as a radiation detector or the like operates to read a detected image, i.e., to output detected image information, if a temperature regulating means, such as a cooling fan or the like, is energized to regulate the temperature of the image detector, the drive signal that energizes the temperature regulating means may potentially be added to the image information, thus degrading the quality of the read image.

If the image detector is continuously kept at a certain temperature under temperature regulation control in order to achieve a desired performance of the image detector, then energy is wastefully consumed for carrying out the temperature regulation control process. Japanese Laid-Open Patent Publication No. 2003-014860 discloses nothing concerning specific details of temperature regulation upon reading a detected image from the radiation detector.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an image detecting device and an image capturing system, which avoid unnecessary temperature regulation control so as to save energy, and which are capable of obtaining high-quality images.

An image detecting device according to the present invention comprises an image detector for recording an image therein and outputting the recorded image as image information, a temperature regulation controller for performing a temperature regulation control operation in order to adjust the image detector to a predetermined temperature, an image information output detector for detecting the output of image information from the image detector and outputting the detected output as an image information output detection signal to the temperature regulation controller, and a timer. The temperature regulation controller stops or relaxes a temperature regulation control operation on the image detector based on the image information output detection signal input thereto, and resumes or stops relaxing the temperature regulation control operation on the image detector when the timer has measured a preset period of time after having stopped or relaxed the temperature regulation control operation.

When an image is read, i.e., when image information is output, the temperature regulation controller stops or relaxes the temperature regulation control operation on the image detector. When the timer has measured the preset period of time after the temperature regulation control operation has been stopped or relaxed, the temperature regulation controller resumes the normal temperature regulation control operation on the image detector. As a result, noise caused by the temperature regulation control operation is prevented from being added to the image, i.e., to the image information, and hence the image that is produced is high in quality.

Furthermore, the normal temperature regulation control operation is resumed upon elapse of the preset period of time after the temperature regulation control operation has been temporarily shut off or relaxed. Therefore, the temperature regulation control operation is appropriately performed only during time periods other than when the image is read. Accordingly, the radiation detector remains stably operational. As a result, unnecessary temperature regulation control is avoided in order to save energy consumed by the radiation detecting device, and by the overall image capturing system that incorporates the radiation detecting device therein.

The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an image capturing system according to an embodiment of the present invention;

FIG. **2** is a perspective view of the radiation solid-state detecting device shown in FIG. **1**, with a cooling panel disposed on the rear surface of a sensor substrate;

FIG. **3** is a block diagram of the radiation solid-state detecting device shown in FIG. **1**;

FIG. **4** is a detailed block diagram of a signal reading circuit shown in FIG. **3**;

FIG. **5** is a fragmentary cross-sectional view of the sensor substrate and the cooling panel shown in FIG. **2**;

FIG. **6** is a plan view showing the layout of Peltier devices disposed in each of the cooling units shown in FIG. **2**;

FIG. **7** is a perspective view of a mammographic apparatus which incorporates the image capturing system shown in FIG. **1**;

FIG. **8** is a fragmentary vertical elevational view, partly in cross section, showing internal structural details of an image capturing base of the mammographic apparatus shown in FIG. **7**; and

FIG. **9** is a view showing a radiation solid-state detecting device according to another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. **1**, an image capturing system **20** according to an embodiment of the present invention comprises a radiation generator **24** for generating and applying radiation X to a subject **22**, typically a patient, a radiation solid-state detecting device (an image detecting device, a radiation image information detecting device) **26** for detecting radiation X that has passed through the subject **22**, a controller **28** for controlling the radiation generator **24** and the radiation solid-state detecting device **26**, a console **30** for setting image capturing conditions such as a radiation dose for the radiation X to be applied to the subject **22** in the controller **28**, an image processor **32** for processing radiation image information of the subject **22**, which is read from the radiation solid-state detecting device **26**, and a display device **34** for displaying the processed radiation image information.

The radiation solid-state detecting device **26** comprises a sensor substrate (image detector) **38**, a gate line driving circuit **44**, a battery **45**, a signal reading circuit **46**, a timing control circuit **48**, a temperature regulation controller **135**, an area specifying unit **134**, a communication unit **136**, a timing control signal detector (image information output detector) **270**, an exposure detector (image recording detector) **272**, and a timer (time measuring unit) **280**. The temperature regulation controller **135** comprises a cooling panel **130** and a cooling panel energizing unit **132**. The cooling panel energizing unit **132** comprises a temperature controller **133**, a temperature sensor **138**, and a fan (a cooling fan) **140**.

FIG. **2** shows the radiation solid-state detecting device **26** in perspective. As shown in FIG. **2**, the radiation solid-state detecting device **26** comprises a sensor substrate **38** housed in a protective casing **36** for storing (recording) radiation image information carried by radiation X that has passed through the subject **22** (see FIG. **1**) as two-dimensional electric charge information, and a cooling panel **130** held closely against a rear surface of the sensor substrate **38**, which is opposite to a front surface thereof that is irradiated with radiation X.

The cooling panel **130** is disposed substantially fully over the rear surface of the sensor substrate **38**, and comprises nine rectangular cooling units **142***a* through **142***i* placed on the rear surface of the sensor substrate **38**.

FIG. **3** shows the radiation solid-state detecting device **26** in block form. As shown in FIG. **3**, the radiation solid-state detecting device **26** comprises the sensor substrate **38**, a gate line driving circuit **44** having a plurality of driving ICs, not shown, a signal reading circuit **46** having a plurality of reading ICs **42** (see FIG. **4**), and a timing control circuit **48** for controlling the gate line driving circuit **44** and the signal reading circuit **46**.

The sensor substrate **38** comprises an array of thin-film transistors (TFTs) **52** arranged in rows and columns, a photoelectric conversion layer **51** made of a material such as amorphous selenium (a-Se) for generating electric charges upon detection of radiation X, the photoelectric conversion layer **51** being disposed on the array of TFTs **52**, and an array of storage capacitors **53** connected to the photoelectric conversion layer **51**. When radiation X is applied to the sensor substrate **38**, the photoelectric conversion layer **51** generates electric charges, and the storage capacitors **53** store the generated electric charges therein. Then, the TFTs **52** are turned on, each row at a time, in order to read the electric charges from the storage capacitors **53** as an image signal. In FIG. **3**, the photoelectric conversion layer **51** and one of the storage capacitors **53** are shown as making up a pixel **50**, wherein the pixel **50** is connected to one of the TFTs **52**. Details of the other pixels **50** are omitted from illustration. Since amorphous selenium tends to change in structure and lose functions thereof at high temperatures, amorphous selenium needs to be used within a certain temperature range. Therefore, some means for cooling the sensor substrate **38** should preferably be provided in the radiation solid-state detecting device **26**. The TFTs **52** connected to the respective pixels **50** are connected to respective gate lines **54** extending parallel to the rows, and to respective signal lines **56** extending parallel to the columns. The gate lines **54** are connected to the gate line driving circuit **44**, and the signal lines **56** are connected to the signal reading circuit **46**.

FIG. **4** shows the signal reading circuit **46** in detailed block form. As shown in FIG. **4**, the signal reading circuit **46** comprises a plurality of reading ICs **42** connected to the respective signal lines **56** of the sensor substrate **38** (see FIGS. **1** through **3**), a multiplexer **60** for selecting pixels **50** connected to one of the signal lines **56** based on timing signals from the timing control circuit **48**, and an A/D converter **62** for converting radiation image information read from the selected pixels into digital image signals and sending (outputting) the digital image signals via the communication unit **136** to the image processor **32**.

Each of the reading ICs **42** comprises an operational amplifier (integrating amplifier) **66** for detecting current supplied from the signal line **56** through a resistor **64**, an integrating capacitor **68**, and a switch **70**. The operational amplifier **66** has an inverting input terminal connected to the signal line **56** through the resistor **64**, and a non-inverting input terminal supplied with a reference voltage Vb.

FIG. **5** shows in fragmentary cross section the sensor substrate **38** and the cooling panel **130** (see FIGS. **1** and **2**).

Each of the cooling units **142***a* through **142***i* of the cooling panel **130** comprises a plurality of Peltier devices **156**.

Specifically, each of the cooling units **142***a* through **142***i* comprises an endothermic substrate **146** held closely against the rear surface of the sensor substrate **38**, a plurality of endothermic electrodes **148** disposed at given spaced intervals on the endothermic substrate **146**, P-type semiconductor devices **152** and N-type semiconductor devices **154** joined respectively to opposite ends of the endothermic electrodes **148**, a plurality of exothermic electrodes **150** each interconnecting the P-type semiconductor device **152** connected to one of the endothermic electrodes **148** and the N-type semiconductor device **154** connected to an adjacent one of the endothermic electrodes **148**, and an exothermic substrate **158** held closely against the exothermic electrodes **150**.

In FIG. **5**, the endothermic substrate **146**, the endothermic electrodes **148**, the P-type semiconductor devices **152** and the N-type semiconductor devices **154**, the exothermic electrodes **150**, and the exothermic substrate **158** are stacked successively in this order downwardly from the rear surface of the sensor substrate **38**, thereby making up each of the cooling units **142***a* through **142***i*.

Each of the Peltier devices **156** is made up of two adjacent endothermic electrodes **148**, an exothermic electrode **150** extending between the two endothermic electrodes **148**, and a P-type semiconductor device **152** and an N-type semiconductor device **154** that are interconnected by the exothermic electrode **150**. The temperature controller **133** comprises a DC power supply **144** connected to the endothermic electrode **148** that is joined to the leftmost P-type semiconductor device **152** in FIG. **5**, and the endothermic electrode **148** that is joined to the rightmost N-type semiconductor device **154** in FIG. **5**.

The endothermic substrate **146** and the exothermic substrate **158** are preferably made of a thermally conductive material, e.g., ceramics exhibiting a thermal conductivity that is oriented from the sensor substrate **38** toward the cooling units **142***a* through **142***i*.

As described above, the photoelectric conversion layer **51** (see FIG. **3**) of the sensor substrate **38** is made of amorphous selenium. Since amorphous selenium tends to change in structure and lose functions thereof at high temperatures, amorphous selenium needs to be used within a certain temperature range. The radiation solid-state detecting device **26** includes the temperature regulation controller **135** (see FIG. **1**) for cooling the sensor substrate **38** when the temperature of the photoelectric conversion layer **51** (amorphous selenium) exceeds the temperature range, thereby keeping the temperature of the photoelectric conversion layer **51** within the given temperature range.

The temperature sensor **138** of the temperature regulation controller **135**, which is disposed near the sensor substrate **38**, detects the temperature of the sensor substrate **38** depending on the temperature of the amorphous selenium, at all times or at certain time intervals, and outputs the detected temperature of the sensor substrate **38** to the temperature controller **133**. The temperature controller **133** determines whether the input temperature of the sensor substrate **38** exceeds a given upper-limit temperature depending on the upper-limit value of the temperature range for the photoelectric conversion layer **51** (amorphous selenium). If the temperature controller **133** judges that the temperature of the sensor substrate **38** has exceeded the upper-limit temperature, then the temperature controller **133** supplies direct current from the DC power supply **144** to the Peltier devices **156**, and energizes the fan **140**. When the Peltier devices **156** are supplied with direct current, they exhibit a phenomenon referred to as the Peltier effect. Specifically, the junctions between the endothermic electrodes **148** and the P-type semiconductor devices **152** and the N-type semiconductor devices **154** absorb heat from the amorphous selenium in the sensor substrate **38** through the endothermic substrate **146**, and the junctions between the P-type semiconductor devices **152** and the N-type semiconductor devices **154** and the exothermic electrodes **150** radiate heat that has been transferred from the junctions of the endothermic electrodes **148** through the P-type semiconductor devices **152** and the N-type semiconductor devices **154**, through the exothermic substrate **158**, and out of the cooling panel **130**. The fan **140** applies air to the exothermic substrate **158** to cool the exothermic substrate **158** and to promote the radiation of heat therefrom.

The upper-limit temperature referred to above may be preregistered in the temperature controller **133**, or it may be pre-registered as one of the image capturing conditions in the controller **28**, and transmitted from the controller **28** via the communication unit **136** to the temperature controller **133** before a radiation image is captured.

FIG. **6** shows in plan view the layout of the Peltier devices **156** disposed in each of the cooling units **142***a* through **142***i*. The sensor substrate **38** and the exothermic substrate **158** (see FIGS. **1** through **3**, **5**) are omitted from illustration. In FIG. **6**, the Peltier devices **156** are shown as viewed in a direction from the exothermic substrate **158** toward the sensor substrate **38**.

As shown in FIG. **6**, in each of the cooling units **142***a* through **142***i*, the Peltier devices **156** are arrayed in a matrix on the endothermic substrate **146**. When the Peltier devices **156** are supplied with direct current from the DC power supply **144**, each of the Peltier devices **156** absorbs heat from the amorphous selenium of the sensor substrate **38** and radiates heat through the exothermic substrate **158** (see FIG. **5**) and out of the cooling panel **130**. The temperature controller **133** (see FIG. **1**) of the cooling panel energizing unit **132** can selectively supply direct current from the DC power supply **144** to the cooling units **142***a* through **142***i* and radiate the heat of the amorphous selenium in given areas of the sensor substrate **38**, which face the cooling units **142***a* through **142***i*, through the cooling units **142***a* through **142***i* and out of the cooling panel **130**.

The area specifying unit **134** (see FIG. **1**) specifies pixels **50** in which to record radiation image information based on the image capturing conditions transmitted from the controller **28** via the communication unit **136**, and outputs data from each of the specified pixels **50** as a recording area for the radiation image information to the timing control circuit **48**, the temperature controller **133**, the timing control signal detector **270**, and the exposure detector **272**. Therefore, the controller **28** preferably should send the image capturing conditions to the area specifying unit **134** in order to cause the area specifying unit **134** to specify the recording areas, before the subject **22** is irradiated with radiation X, or more specifically, before the radiation X reaches the irradiated surface of the sensor substrate **38** and stores electric charges in the storage capacitors **53** (see FIG. **3**).

Based on the supplied recording areas, the timing control circuit **48** outputs a timing control signal to the gate line driving circuit **44** and the signal reading circuit **46**, in order to read image signals from the specified pixels **50**. Based on the supplied recording areas, the temperature controller **133** supplies direct current from the DC power supply **144** to the Peltier devices **156** (see FIGS. **5** and **6**) of the cooling units **142***a* through **142***i*, which face the specified pixels **50**.

The timing control signal detector **270** detects the timing control signal output from the timing control circuit **48**, and outputs the detected timing control signal as an image information output detection signal to the temperature controller **133**. Specifically, since the radiation image information is read from the pixels **50** (see FIG. **3**) as recording areas in response to the timing control signal output from the timing control circuit **48** to the gate line driving circuit **44** and the signal reading circuit **46**, the timing control signal detector **270** detects the reading of radiation image information from the pixels **50**, and outputs the detected reading as the image information output detection signal to the temperature controller **133** and to the timer **280**. Since the area specifying unit **134** outputs the recording areas to the timing control signal detector **270**, the timing control signal detector **270** is able to monitor (detect) whether or not the timing control circuit **48** has supplied the timing control signal for only the pixels **50** as the recording areas.

Based on the recording areas supplied from the area specifying unit **134**, the exposure detector **272** detects the storage of electric charges in the storage capacitors **53**, or the generation of electric charges in the photoelectric conversion layer **51** of those pixels **50** which are not specified as recording areas, and outputs the detected storage or generation as an image recording detection signal to the temperature controller **133** and to the timer **280**. Specifically, when electric charges are stored in the storage capacitors **53** or generated in the photoelectric conversion layer **51** by exposure to radiation X, the radiation image information is recorded in the pixels **50**. The exposure detector **272** detects the recording of radiation image information in the unspecified pixels **50**, i.e., the exposure to radiation X, and outputs the detected recording as the image recording detection signal to the temperature controller **133** and to the timer **280**.

When the temperature controller **133** is supplied with the image recording detection signal and/or the image information output detection signal, the temperature controller **133** judges that radiation image information is being recorded or that the recorded radiation image information is being read. The temperature controller **133** then stops supplying direct current from the DC power supply **144** to the Peltier devices **156** and de-energizes the fan **140**, thereby temporarily stopping the performing of temperature regulation on the sensor substrate **38**.

The timer **280** starts measuring time from the time (stop time) when direct current stops being supplied from the DC power supply **144** to the Peltier devices **156**. When the timer **280** has measured a preset period of time from the stop time, the timer **280** outputs a timing signal representing the measured preset time period to the temperature controller **133**.

Since the timing control signal detector **270** outputs the image information output detection signal to the timer **280**, and the exposure detector **272** outputs the image recording detection signal to the timer **280**, the timer **280** measures time from the stop time to a time when the timer **280** stops being supplied with the image information output detection signal or with the image recording detection signal, and outputs the timing signal to the temperature controller **133** at the time when the timer **280** stops being supplied with the image information output detection signal or with the image recording detection signal. Therefore, the preset period of time referred to above represents a period of time from the stop time to the time when the timer **280** stops being supplied with the image information output detection signal or with the image recording detection signal.

Based on the timing signal supplied from the timer **280** to the temperature controller **133**, the temperature controller **133** judges that recording or reading of the radiation image information has been completed. The temperature controller **133** supplies direct current from the DC power supply **144** to the Peltier devices **156** and energizes the fan **140**, thereby resuming temperature regulation on the sensor substrate **38**.

The image capturing system **20** basically is constructed as described above. Operations of the image capturing system **20** will be described below with reference to FIGS. **1** through **6**.

Using the console **30**, the operator, typically a radiological technician, sets ID information concerning the subject **22**, image capturing conditions, etc. The ID information includes information as to the name, age, sex, etc., of the subject **22**, which can be acquired from an ID card possessed by the subject **22**. The image capturing conditions include, in addition to information concerning the region of the subject **22** to be imaged, an image capturing direction, etc., as specified by the doctor in charge of the subject **22**, an irradiation dose of the radiation X depending on the region to be imaged, and the upper-limit temperature for the sensor substrate **38**, which corresponds to the upper-limit value of the temperature range for amorphous selenium. If the image capturing system **20** is connected to a network, then these items of information can be acquired from a higher-level apparatus through the network. Alternatively, such items of information can be entered from the console **30** by an operator.

After the region to be imaged of the subject **22** has been positioned with respect to the radiation solid-state detecting device **26**, the controller **28** controls the radiation generator **24** and the radiation solid-state detecting device **26** according to set image capturing conditions. Based on the image capturing conditions sent from the controller **28** via the communication unit **136**, the area specifying unit **134** of the radiation solid-state detecting device **26** specifies pixels **50** in which to record radiation image information, and outputs each of the specified pixels **50** as a recording area for the radiation image information to the timing control circuit **48**, the temperature controller **133**, the timing control signal detector **270**, and to the exposure detector **272**.

The temperature sensor **138** detects the temperature of the sensor substrate **38** depending on the temperature of the amorphous selenium, at all times or at certain time intervals, and outputs the detected temperature of the sensor substrate **38** to the temperature controller **133**. Based on the input recording areas, the temperature controller **133** selects corresponding ones from among the cooling units **142*a*** through **142*i*** to which to supply direct current from the DC power supply **144**, and determines whether the temperature of the sensor substrate **38** has exceeded a given upper-limit temperature, depending on the upper-limit value of the temperature range for the photoelectric conversion layer **51** (amorphous selenium), each time that the temperature controller **133** is supplied with the temperature of the sensor substrate **38** from the temperature sensor **138**, which may occur at all times or at certain time intervals.

The radiation generator **24** applies radiation X to the subject **22** according to the image capturing conditions sent from the controller **28**. Radiation X which has passed through the subject **22** is converted into electric signals by the photoelectric conversion layer **51** of the pixels **50** in the specified recording areas in the sensor substrate **38** of the radiation solid-state detecting device **26**. The electric signals are stored as electric charges in the storage capacitors **53** (see FIG. **3**). The stored electric charges, which represent radiation image information of the subject **22**, are read from the storage capacitors **53** according to timing control signals, which are supplied from the timing control circuit **48** to the gate line driving circuit **44** and the signal reading circuit **46**.

As described above, since the area specifying unit **134** outputs the recording areas to the timing control circuit **48**, the timing control circuit **48** outputs timing control signals based on the recording areas to the gate line driving circuit **44** and the signal reading circuit **46**, in order to read image signals from the pixels **50** of the storage capacitors **53** where electric charges have been stored based on the recording areas.

Specifically, the gate line driving circuit **44** selects one of the gate lines **54** according to the timing control signal from the timing control circuit **48**, and supplies a drive signal to bases of the TFTs **52** that are connected to the selected gate line **54**. The multiplexer **60** of the signal reading circuit **46** successively switches between the signal lines **56** connected to the reading ICs **42** in order to select one of the signal lines **56** at a time. An electric charge representing the radiation image information that is stored in the storage capacitor **53** of the pixel **50**, which corresponds to the selected gate line **54** and the selected signal line **56**, is supplied through the resistor **64** to the operational amplifier **66**. The operational amplifier **66** integrates the supplied electric charges and supplies them through the multiplexer **60** to the A/D converter **62**, which converts the electric charges into a digital image signal. The digital image signal is supplied through the communication unit **136** to the image processor **32**. After all the image signals have been read from the pixels **50** connected to the selected gate line **54**, the gate line driving circuit **44** selects the next gate line **54**, and supplies a drive signal to the selected gate line **54**. The signal reading circuit **46** then successively reads image signals from the TFTs **52** connected to the selected gate line **54**, in the same manner as described above. The above operations are repeated to read two-dimensional radiation image information stored in the pixels **50** as specified recording areas in the sensor substrate **38**, and to supply the read two-dimensional radiation image information to the image processor **32**.

Radiation image information supplied to the image processor **32** is processed thereby. The display device **34** displays an image based on the processed radiation image information from the image processor **32** for diagnostic purposes. The doctor makes a diagnosis based on the image displayed on the display device **34**.

The temperature controller **133** (see FIG. **1**) sequentially determines whether (the temperature of the sensor substrate **38** depending on) the temperature of the amorphous selenium in the recording areas has exceeded (the upper-limit temperature of the sensor substrate **38** depending on the upper-limit value of) the temperature range for amorphous selenium. If the temperature controller **133** judges that the temperature of the sensor substrate **38** has exceeded the upper-limit temperature, then the temperature controller **133** selects those from among the cooling units **142***a* through **142***i* which face the recording areas, supplies direct current from the DC power supply **144** to the Peltier devices **156** of the selected cooling units **142***a* through **142***i*, and energizes the fan **140**.

The Peltier devices **156** that are supplied with direct current exhibit a phenomenon referred to as the Peltier effect, i.e., the junctions between the endothermic electrodes **148** and the P-type semiconductor devices **152** and the N-type semiconductor devices **154** absorb heat of the amorphous selenium from the sensor substrate **38** through the endothermic substrate **146**. The junctions between the P-type semiconductor devices **152** and the N-type semiconductor devices **154** and the exothermic electrodes **150** radiate heat that has been transferred from the junctions of the endothermic electrodes **148** through the P-type semiconductor devices **152** and the N-type semiconductor devices **154**, through the exothermic substrate **158** and out of the cooling panel **130**. The fan **140** applies air to the exothermic substrate **158** to cool the exothermic substrate **158** and to promote the radiation of heat therefrom.

If the temperature controller **133** judges that the temperature of the sensor substrate **38** detected by the temperature sensor **138** has become lower than the upper-limit temperature, then the temperature controller **133** stops supplying direct current from the DC power supply **144** to the Peltier devices **156** and de-energizes the fan **140**.

The area specifying unit **134** also outputs the specified recording areas to the timing control signal detector **270** and to the exposure detector **272**. The timing control signal detector **270** monitors (detects) whether the timing control circuit **48** has supplied the timing control signal for only the pixels **50** specified as the recording areas. If the timing control signal detector **270** detects the output of the timing control signal from the timing control circuit **48**, the timing control signal detector **270** outputs the detected output as an image information output detection signal to the temperature controller **133** and to the timer **280**. When the exposure detector **272** detects the storage of electric charges in the storage capacitors **53**, or the generation of electric charges within the photoelectric conversion layer **51** of those pixels **50** which are not specified as the recording areas, based on the recording areas supplied from the area specifying unit **134**, the exposure detector **272** outputs the detected storage or generation as an image recording detection signal to the temperature controller **133** and the timer **280**.

When the temperature controller **133** is supplied with the image recording detection signal and/or the image information output detection signal, the temperature controller **133** judges that radiation image information has started to be recorded in the pixels **50** specified as the recording areas, or that the recorded radiation image information has started to be read from the pixels **50** specified as recording areas. The temperature controller **133** then stops supplying direct current from the DC power supply **144** to the Peltier devices **156** and de-energizes the fan **140**, thereby stopping temperature regulation from being performed on the sensor substrate **38**.

The timer **280** starts measuring time, from a time (stop time) when direct current stops being supplied from the DC power supply **144** to the Peltier devices **156**. Thereafter, when the timer **280** stops being supplied with the image information output detection signal from the timing control signal detector **270**, or with the image recording detection signal from the exposure controller **272**, the timer **280** stops measuring time and outputs a timing signal to the temperature controller **133**.

In response to the timing signal supplied from the timer **280** to the temperature controller **133**, the temperature controller **133** judges that recording or reading of the radiation image information has been completed. The temperature controller **133** supplies direct current from the DC power supply **144** to the Peltier devices **156** and energizes the fan **140**, thereby resuming temperature regulation on the sensor substrate **38**.

In the image capturing system **20** according to the present embodiment, the radiation solid-state detecting device **26** includes the sensor substrate **38**, the temperature regulation controller **135** for performing a temperature regulation control operation to adjust the sensor substrate **38** to a predetermined temperature, the timing control signal detector **270** for detecting the reading (output) of the radiation image information from the sensor substrate **38** and for outputting the detected reading as an image information output detection signal to the temperature regulation controller **135**, and the timer **280**. When the temperature regulation controller **135** is supplied with the image information output detection signal, the temperature regulation controller **135** stops the temperature regulation control operation from being performed on the sensor substrate **38**. When the timer **280** has measured the preset period of time, from a stop time when the temperature regulation control operation on the sensor substrate **38** is stopped, the temperature regulation controller **135** resumes the temperature regulation control operation on the sensor substrate **38** based on the timing signal that is output from the timer **280** to the temperature regulation controller **135**.

Therefore, when radiation image information is read (output), the temperature regulation controller **135** temporarily stops the temperature regulation control operation from being carried out on the sensor substrate based on the image information output detection signal. As a result, noise due to the temperature regulation control operation is prevented from being added to the radiation image (radiation image information), and hence a high quality radiation image is produced.

Since the temperature regulation control operation performed on the sensor substrate **38** is resumed after the preset period of time has elapsed from temporary shutoff of the temperature regulation control operation, the temperature regulation control operation is reliably disabled during time periods in which the temperature regulation control operation is not required, and the temperature regulation control operation is performed appropriately only during time periods other than when radiation image information is being read. Accordingly, the radiation solid-state detecting device **26** operates stably at all times. As a result, unnecessary control of temperature regulation is avoided in order to conserve energy that is consumed by the radiation solid-state detecting device **26** and by the overall image capturing system **20**.

The exposure detector **272** detects the recording of radiation image information in the sensor substrate **38**, i.e., the application of radiation X to the sensor substrate **38**, and outputs the detected recording as an image recording detection signal to the temperature regulation controller **135**. Based on the supplied image recording detection signal and/or the image information output detection signal, the temperature regulation controller **135** temporarily stops the temperature regulation control from being performed on the sensor substrate **38**. The temperature regulation controller **135** thus stops the temperature regulation control operation on the sensor substrate **38** not only when radiation image information is being read (output), but also when radiation image information is recorded. Consequently, noise caused by the temperature regulation control operation is reliably prevented from being added to the radiation image information, and a high quality radiation image is produced.

After the temperature regulation control operation has been temporarily stopped due to the radiation image information starting to be recorded, the temperature regulation controller **135** resumes the temperature regulation control operation, based on a timing signal output from the timer **280** to the temperature regulation controller **135**, once the timer **280** has measured the preset period of time from the stop time. Since the temperature regulation control operation is resumed upon elapse of the preset period of time from temporary stoppage of the temperature regulation control operation, the temperature regulation control operation is reliably disabled during time periods in which the temperature regulation control operation is not required, such as during times when the radiation image information is not being recorded. The temperature regulation control operation is performed appropriately only during time periods other than when radiation image information is being recorded or read. Accordingly, the radiation solid-state detecting device **26** operates stably at all times. As a result, unnecessary temperature regulation control is avoided in order to conserve energy consumed by the radiation solid-state detecting device **26** and by the overall image capturing system **20**.

The timer **280** measures a time from the stop time until a time when reading (outputting) of radiation image information is completed, i.e., at a time when inputting of the image information output detection signal from the timing control signal detector **270** is stopped, or the timer **280** measures a time from the stop time until a time when recording of the radiation image information is completed, i.e., at a time when inputting of the image recording detection signal from the exposure detector **272** is stopped. After having measured the preset period of time, the timer **280** outputs a timing signal to the temperature regulation controller **135** (temperature controller **133**). Accordingly, the temperature regulation controller **135** is capable of resuming the temperature regulation control operation accurately and reliably.

The temperature regulation controller **135** comprises the cooling panel **130**, which is disposed on the rear surface of the sensor substrate **38** for cooling the sensor substrate **38**, and the cooling panel energizing unit **132** for energizing the cooling panel **130**. Therefore, the temperature regulation controller **135** can reliably cool the sensor substrate **38**.

The cooling panel **130** comprises the cooling units **142***a* through **142***i* placed on the rear surface of the sensor substrate **38**. The temperature controller **133** of the cooling panel energizing unit **132** (the temperature regulation controller **135**) energizes those among the cooling units **142***a* through **142***i* that face the specified recording areas. Since the temperature controller **133** selectively energizes the cooling units **142***a* through **142***i* based on the specified recording areas, the specified recording areas are reliably cooled, whereas other areas of the sensor substrate **38** are prevented from being cooled. As a result, the sensor substrate **38** is cooled effectively without wasteful consumption of energy.

The cooling panel energizing unit **132** comprises the temperature controller **133**, the temperature sensor **138**, and the fan **140**. The temperature sensor **138** detects the temperature of the sensor substrate **38** depending on the temperature of the amorphous selenium within the specified recording areas. The temperature controller **133** determines whether or not the detected temperature has exceeded the upper-limit temperature for the sensor substrate **38**, depending on the upper-limit value of the temperature range for amorphous selenium. If the temperature controller **133** judges that the detected temperature has exceeded the upper-limit temperature, then the temperature controller **133** energizes the cooling panel **130** and the fan **140** so that (the temperature of the amorphous selenium indicated by) the temperature of the sensor substrate **38** will drop to (the upper-limit value of the temperature range indicated by) the upper-limit temperature. The fan **140** applies air to the cooling panel **130** for promoting radiation of heat, which is transferred from the sensor substrate **38** to the cooling panel **130**, and out of the cooling panel **130**. Therefore, the cooling panel **130** and the sensor substrate **38** are cooled efficiently.

Each of the cooling units **142***a* through **142***i* comprises the Peltier devices **156**, which are arrayed in a matrix on the endothermic substrate **146** and held closely against the rear surface of the sensor substrate **38**. The temperature controller **133** cools the specified recording areas by supplying direct current from the DC power supply **144** to the Peltier devices **156**. Heat in the sensor substrate **38** is thus reliably radiated out of the cooling panel **130** based on the Peltier effect exhibited by the Peltier devices **156**.

Before radiation image information is recorded in the sensor substrate **38**, the area specifying unit **134** specifies certain pixels **50** within the sensor substrate **38** as pixels **50** for recording radiation image information, based on the image capturing conditions from the controller **28**, and outputs the specified pixels **50** as recording areas to the timing control circuit **48**, the temperature controller **133**, the timing control signal detector **270**, and to the exposure detector **272**.

Based on the recording areas, the timing control circuit **48** outputs timing control signals to the gate line driving circuit **44** and to the signal reading circuit **46**, for thereby reliably reading image signals from the pixels **50** in which radiation image information has been recorded. Based on the recording areas, the temperature controller **133** supplies direct current from the DC power supply **144** to the Peltier devices **156** of those ones from among the cooling units **142***a* through **142***i* that correspond to the recording areas. Based on the recording areas, the timing control signal detector **270** efficiently detects output of the timing control signal. Based on the recording areas, the exposure detector **272** reliably and efficiently detects the storage of electric charges in the storage capacitors **53**, or the generation of electric charges (application of radiation X) in the photoelectric conversion layer **51** of those pixels **50** that are not specified as recording areas.

In the above description, the preset period of time measured by the timer **280** is a period of time from the stop time, referred to above, to the time when the timer **280** stops being supplied with either the image information output detection signal or the image recording detection signal. However, the preset period of time may be set to different periods of time. For example, the timer **280** may supply the timing signal to the temperature controller **133** after elapse of a predetermined period of time from the time the timer **280** stops being supplied with either the image information output detection signal or the image recording detection signal.

Alternatively, if the period of time (reading time) required to read radiation image information from the sensor substrate **38** and the period of time (recording time) required to record radiation image information in the sensor substrate **38** are known in advance, then the reading time and the recording time may be pre-registered in the timer **280**. The timer **280** may then supply the timing signal to the temperature controller **133** when the timer **280** measures the reading time or the recording time from the stop time. In this case, the timer **280** does not need to be supplied with the image information output detection signal or with the image recording detection signal.

In the above description, the cooling panel **130** is disposed on the rear surface of the sensor substrate **38**. However, the cooling panel **130** may also be disposed on the irradiated surface of the sensor substrate **38**. Even if the cooling panel **130** is disposed on the irradiated surface of the sensor substrate **38**, since the cooling panel **130** is disposed on a surface of the sensor substrate **38**, the cooling panel **130** offers the same advantages described above according to the present invention.

If the cooling panel **130** is disposed on the irradiated surface of the sensor substrate **38**, then the cooling panel **130** should be made of a material that is permeable to radiation X. Since the endothermic electrodes **148**, the P-type semiconductor devices **152**, the N-type semiconductor devices **154**, and the exothermic electrodes **150** of each of the cooling units **142***a* through **142***i* contain metals therein, a portion of the radiation X applied to the sensor substrate **38** may potentially be absorbed by such metals. To avoid such a drawback, the layout pattern of the Peltier devices **156** within the cooling units **142***a* through **142***i* may be pre-registered, such that when radiation image information is input thereto, a reduction in quality of the radiation image information may be compensated for by an image processing process based on the registered layout pattern. In this manner, the radiation image information is prevented from being adversely affected due to undue absorption of radiation X by the metals.

In the above description, the temperature regulation controller **135** resumes the temperature regulation control operation based on the timing signal from the timer **280**. After the temperature regulation controller **135** has resumed the temperature regulation control operation, the temperature controller **133** of the temperature regulation controller **135** performs the following processing operations:

The timer **280** starts measuring a time period, from the time when the timer **280** outputs the timing signal, i.e., from the time (resumption time) when the temperature regulation control operation is resumed. When the timer **280** has measured a preset period of time from the resumption time, the timer **280** outputs a new timing signal to the temperature controller **133**, and the temperature controller **133** once again stops the resumed temperature regulation control operation, based on the new timing signal input thereto. Therefore, the overall temperature regulation controller **135** conserves electrical energy, and avoids unnecessary temperature regulation control.

The timer **280** starts measuring a time period, from the time when the timer **280** outputs the timing signal, i.e., from the time (resumption time) when the temperature regulation control operation is resumed. When the timer **280** has measured a preset period of time from the resumption time, the timer **280** outputs a new timing signal to the temperature controller **133**. Based on the new timing signal input to the temperature controller **133**, the temperature controller **133** outputs a ready signal (recordable signal) via the communication unit **136** to the controller **28**, which indicates that a radiation image can be recorded in the sensor substrate **38**. Specifically, when the temperature regulation control operation is performed for a certain period of time from the resumption time, the temperature of the amorphous selenium in the sensor substrate **38** becomes stable within a given temperature range. Based on the new timing signal input to the temperature controller **133**, the temperature controller **133** sends a ready signal to the controller **28**, which can recognize that the temperature of the amorphous selenium has been stabilized as a result of the temperature regulation control operation, thereby making it possible to record a radiation image in the sensor substrate **38**. Based on the ready signal input to the controller **28**, the controller **28** can control the radiation generator **24** in order to start applying radiation X to the subject **22**.

In the present embodiment, instead of the above structure, the temperature regulation control unit **135** may relax the temperature regulation control operation on the sensor substrate **38** based on the image recording detection signal and/or the image information output detection signal, and then after the timer **280** has measured a preset period of time the temperature regulation control unit **135** may stop relaxing to resume the normal temperature regulation control operation. The timer **280** may restart measuring time when the temperature regulation control operation is resumed. Then, when the timer **280** has measured another preset period of time after the temperature regulation control unit **135** has stopped relaxing the temperature regulation control operation, a new time measurement signal is output to the temperature controller **133** of the temperature regulation control unit **135**. The temperature controller **133** may relax the temperature regulation control operation again based on the new time measurement signal input, or may output a ready signal to the controller **28** via a communication unit **136**.

The temperature regulation control operation may be relaxed by reducing the rotation number of the fan **140** of the temperature regulation control means **135** to half, preferably to ⅓, of the rotation number in the normal operation. The temperature regulation control operation may also be relaxed by reducing the amount of the direct current supplied to the Peltier devices **156** to half, preferably to ⅓, of the amount of the direct current supplied thereto in the normal operation.

By controlling the rotation number of the fan **140** and/or the amount of current supplied to the Peltier devices **156** without stopping the temperature regulation control operation temporally, the same advantages as the aforementioned embodiment can be achieved.

Alternatively, when the temperature regulation control is operated by using both the fan **140** and the Peltier devices **156**, the temperature regulation control unit **135** may relax the temperature regulation control operation on the sensor substrate **38** based on the image recording detection signal and/or the image information output detection signal by stopping either the operation of the fan **140** or the operation of the Peltier devices **156**.

FIG. **7** shows in perspective a mammographic apparatus **170** utilized for breast cancer screening, which incorporates the image capturing system **20** according to the present embodiment.

As shown in FIG. **7**, the mammographic apparatus **170** includes an upstanding base **172**, a vertical arm **176** fixed to a horizontal swing shaft **174** disposed substantially centrally on the base **172**, a radiation source housing unit **180** housing therein a radiation source (not shown) for applying radiation X to a breast **179** (see FIG. **8**) of a subject **22** to be imaged and which is fixed to an upper end of the arm **176**, an image capturing base **182** mounted on a lower end of the arm **176** in confronting relation to the radiation source housing unit **180**, and a compression plate **184** for compressing and holding the breast **179** against the image capturing base **182**.

When the arm **176**, to which the radiation source housing unit **180** and the image capturing base **182** are secured, is angularly moved about the swing shaft **174** in the directions indicated by the arrow A, an image capturing direction with respect to the breast **179** of the subject **22** can be adjusted. The compression plate **184** coupled to the arm **176** is disposed between the radiation source housing unit **180** and the image capturing base **182**. The compression plate **184** is vertically displaceable along the arm **176** in the directions indicated by the arrow B.

A display control panel **186** is connected to the base **172** for displaying image capturing information including an image capturing region, an image capturing direction, etc., of the subject **22**, which have been detected by the mammographic apparatus **170**, the ID information of the subject **22**, etc., and for enabling setting of these items of information, if necessary. The display control panel **186** includes functions that are part of the functions of the console **30** and the display device **34** (see FIG. **1**).

FIG. **8** shows the internal structural details of the image capturing base **182** of the mammographic apparatus **170**. In FIG. **8**, the breast **179** of the subject **22** to be imaged is shown as being placed between the image capturing base **182** and the compression plate **184**.

The image capturing base **182** houses therein the radiation solid-state detecting device **26** for storing radiation image information, which is captured based on radiation X output from the radiation source in the radiation source housing unit **180**, and outputting an electric signal representative of the stored radiation image information. In FIG. **8**, the cooling panel **130**, which is made up of cooling units **142*j*** through **1421**, is disposed on the rear surface of the sensor substrate **38**.

In the mammographic apparatus **170** shown in FIGS. **7** and **8**, the cooling panel **130** is disposed on the rear surface of the sensor substrate **38**. However, the cooling panel **130** may also be disposed on the irradiated surface of the sensor substrate **38**.

The radiation solid-state detecting device **26** including the cooling panel **130** disposed on the surface of the sensor substrate **38** is housed in the image capturing base **182**. The mammographic apparatus **170** offers the same advantages described above according to the present invention. That is, when the breast **179** touches the radiation solid-state detecting device **26**, the body temperature of the subject **22** is transmitted to the sensor substrate **38** through the breast **179** so that the temperature of the sensor substrate **38** rises. Therefore, the region of the sensor substrate **38** corresponding to the region where the breast **179** touches is cooled.

FIG. **9** shows a light readout type radiation solid-state detecting device **190** according to another embodiment of the present invention. Unlike the direct conversion type radiation solid-state detecting device **26** shown in FIG. **3** employing TFTs **52**, the light readout type radiation solid-state detecting device **190** has a sensor substrate **200** for storing radiation image information as an electrostatic latent image, and which enables reading of the electrostatic latent image as electric charge information when the sensor substrate **200** is irradiated with reading light L from a reading light source **210**.

The sensor substrate **200** comprises a first electrode layer **204** permeable to radiation X, a recording photoconductive layer **206** that becomes electrically conductive when irradiated with radiation X, a charge transport layer **208**, which acts substantially as an electric insulator with respect to latent image electric charges and as an electric conductor with respect to transport electric charges that have a polarity opposite to the latent image electric charges, a reading photoconductive layer **212** that becomes electrically conductive when irradiated with reading light L from the reading light source **210**, and a second electrode layer **214** permeable to the reading light L. The layers are successively arranged in this order, from the surface of the sensor substrate **200** that is irradiated with the radiation X.

A charge storage region **216** for storing the electric charges generated by the recording photoconductive layer **206** is disposed between the recording photoconductive layer **206** and the charge transport layer **208**. The second electrode layer **214** comprises a number of linear electrodes **218** extending in the direction indicated by the arrow C, which is perpendicular to the direction in which the reading light source **210** extends. The first electrode layer **204** and the linear electrodes **218** of the second electrode layer **214** are connected to a signal reading circuit **220** for reading electric charge information from the latent image electric charges stored in the charge storage region **216**.

The signal reading circuit **220** comprises a power supply **222** and a switch **224** for applying a given voltage between the first electrode layer **204** and the second electrode layer **214** of the sensor substrate **200**, a plurality of current detecting amplifiers **226** connected to the linear electrodes **218** of the second electrode layer **214** for detecting currents representing the radiation image information as latent image electric charges, a plurality of resistors **230** connected to the current detecting amplifiers **226**, a multiplexer **234** for successively switching between output signals from the current detecting amplifiers **226**, and an A/D converter **236** for converting analog image signals from the multiplexer **234** into digital image signals. Each of the current detecting amplifiers **226** comprises an operational amplifier **238**, an integrating capacitor **240**, and a switch **242**.

In FIG. **9**, the cooling panel **130** is disposed on the irradiated surface of the sensor substrate **200**. However, the cooling panel **130** may also be disposed on the rear surface of the sensor substrate **200**.

The radiation solid-state detecting device **190** shown in FIG. **9** operates as follows: The switch **224** is operated to connect the movable contact thereof to the power supply **222**, to apply a voltage between the first electrode layer **204** and the second electrode layer **214**, whereupon radiation X is applied to the subject **22** (see FIG. **1**). Radiation X that has passed through the subject **22** is applied through the first electrode layer **204** to the recording photoconductive layer **206**. The recording photoconductive layer **206** becomes electrically conductive and generates electric charge pairs. Among the generated electric charge pairs, positive electric charges are combined with negative electric charges supplied from the power supply **222** to the first electrode layer **204**, and the positive electric charges disappear. The negative electric charges generated by the recording photoconductive layer **206** move toward the charge transport layer **208**. Since the charge transport layer **208** acts substantially as an electric insulator with respect to the negative electric charges, the negative electric charges are stored as an electrostatic latent image in the charge storage region **216**, which is present as an interface between the recording photoconductive layer **206** and the charge transport layer **208**.

After the electrostatic latent image has been stored in the sensor substrate **200**, the signal reading circuit **220** reads the radiation image information. The switch **224** is operated to connect the movable contact thereof between the non-inverting input terminals of the operational amplifiers **238** of the current detecting amplifiers **226** and the first electrode layer **204** of the sensor substrate **200**.

While the reading light source **210** moves in the auxiliary scanning direction indicated by the arrow C, the reading light source **210** applies reading light L to the reading photoconductive layer **212**. The switches **242** of the current detecting amplifiers **226** are turned on and off in the auxiliary scanning direction at intervals corresponding to the pixel pitch, for thereby reading the radiation image information as electric charge information representing the electrostatic latent image.

When reading light L is applied through the second electrode layer **214** to the reading photoconductive layer **212**, the reading photoconductive layer **212** becomes electrically conductive and generates electric charge pairs. Among the generated electric charge pairs, positive electric charges reach the charge storage region **216** through the charge transport layer **208**, which acts substantially as an electric insulator with respect to the positive electric charges. In the charge storage region **216**, the positive electric charges are combined with negative electric charges, which represent the electrostatic latent image stored in the charge storage region **216**, and the positive electric charges disappear. The negative electric charges generated by the reading photoconductive layer **212** are recombined with the positive electric charges of the linear electrodes **218** of the second electrode layer **214**, and the negative electric charges disappear. When the electric charges disappear, currents are generated by the linear electrodes **218** and read by the signal reading circuit **220** as electric charge information, which represents the radiation image information.

The currents generated by the linear electrodes **218** are integrated by the current detecting amplifiers **226** and supplied as voltage signals to the multiplexer **234**. The multiplexer **234** successively switches between the current detecting amplifiers **226** in the main scanning direction along which the linear electrodes **218** are arrayed, and supplies voltage signals to the A/D converter **236**. The A/D converter **236** converts the supplied voltage signals, which form an analog image signal, into a digital image signal, and supplies the digital image signal representing the radiation image information to the image processor **32**. Each time that radiation image information is read from an array of pixels across the auxiliary scanning direction, the switches **242** of the current detecting amplifiers **226** are turned on to discharge the electric charges stored in the integrating capacitors **240**. The above operations are repeated while the reading light source **210** moves in the auxiliary scanning direction, as indicated by the arrow C, in order to read the two-dimensional radiation image information stored in the sensor substrate **200**.

In the image capturing system **20**, which incorporates the radiation solid-state detecting device **190** therein, the cooling panel **130** is disposed on the surface of the sensor substrate **38**. Therefore, the image capturing system **20** that incorporates the radiation solid-state detecting device **190** offers the same advantages described above according to the present invention.

Rather than the direct conversion type radiation solid-state detecting device **26** or the light readout type radiation solid-state detecting device **190** for converting applied radiation X directly into electric charge information, an indirect conversion type radiation detector including a scintillator for converting applied radiation X into visible light may be employed, together with a detecting device for converting the visible light into electric charge information.

Instead of the TFTs **52**, such a device as a CCD (Charge Coupled Device), a CMOS (Complementary Metal Oxide Semiconductor) device or the like may be used for a direct or indirect conversion type radiation detecting device.

Although certain preferred embodiments of the present invention have been shown and described in detail, it should be understood that various changes and modifications may be made to the embodiments without departing from the scope of invention as set forth in the appended claims.

What is claimed is:

1. An image detecting device comprising:

an image detector for recording an image therein and outputting the recorded image as image information;

a temperature regulation controller for performing a temperature regulation control operation in order to adjust the image detector to a predetermined temperature;

an image information output detector for detecting the output of the image information from the image detector, and outputting the detected output as an image information output detection signal to the temperature regulation controller; and

a timer,

wherein the temperature regulation controller stops a temperature regulation control operation on the image detector based on the image information output detection signal input thereto, and resumes the temperature regulation control operation on the image detector when the timer has measured a preset period of time after the temperature regulation control operation has been stopped.

2. An image detecting device according to claim **1**, further comprising:

an image recording detector for detecting the recording of the image in the image detector, and outputting the detected recording as an image recording detection signal to the temperature regulation controller,

wherein the temperature regulation controller stops the temperature regulation control operation on the image detector based on the image recording detection signal or the image information output detection signal input thereto, and resumes the temperature regulation control operation on the image detector when the timer has measured a preset period of time after the temperature regulation control operation has been stopped.

3. An image detecting device according to claim **2**, wherein the timer measures a preset period of time from a time when the temperature regulation controller stops the temperature regulation control operation to a time when the output of the image information has been completed, or from the time when the temperature regulation controller stops the temperature regulation control operation to a time when recording of the image has been completed.

4. An image detecting device according to claim **2**, further comprising:

an area specifying unit for specifying a pixel for recording the image in the image detector, and outputting the specified pixel as a recording area for the image information to the temperature regulation controller, the image information output detector, and the image recording detector;

wherein the image information output detector detects the image information output from the pixel as the recording area;

the image recording detector detects the image recorded in a pixel that is not specified as the recording area in the image detector; and

the temperature regulation controller performs the temperature regulation control operation on the pixel of the recording area.

5. An image detecting device according to claim **1**, wherein the temperature regulation controller again stops the resumed temperature regulation control operation, when the timer has measured a preset period of time from a time when the temperature regulation controller has resumed the temperature regulation control operation.

6. An image detecting device according to claim **1**, wherein the temperature regulation controller outputs a recordable signal indicating that the image can be recorded in the image recorder to an outside, when the timer has measured a preset period of time from the time when the temperature regulation controller has resumed the temperature regulation control operation.

7. An image detecting device according to claim **1**, wherein the temperature regulation controller comprises:

a cooling panel disposed on a surface of the image detector for cooling the image detector; and

a cooling panel energizing unit for energizing the cooling panel.

8. An image detecting device according to claim **7**, wherein the cooling panel comprises:

a plurality of cooling units disposed on the surface of the image detector,

wherein the cooling panel energizing unit energizes those from among the cooling units that correspond to recording areas of the image detector in which the image is recorded.

9. An image detecting device according to claim **7**, wherein the cooling panel energizing unit comprises:

a temperature sensor for detecting a temperature of the image detector;

a temperature controller for energizing the cooling panel to cool the image detector in order to lower the temperature thereof to a predetermined temperature; and

a cooling fan for applying air to the cooling panel to cool the cooling panel.

10. An image detecting device according to claim **7**, wherein the cooling panel comprises a matrix of Peltier devices disposed on the surface of the image detector,

wherein the cooling panel energizing unit supplies current to the Peltier devices to cool the image detector.

11. An image detecting device according to claim **1**, wherein the image detecting device comprises a radiation image information detecting device, wherein the image detector records radiation having passed through a subject and applied to a surface of the image detector as a radiation image, and outputs the recorded radiation image as radiation image information;

the cooling panel is disposed on either the surface of the image detector that is irradiated with the radiation, or on an opposite rear surface of the image detector; and

the cooling panel is permeable to the radiation if the cooling panel is disposed on the surface of the image detector that is irradiated with the radiation.

12. An image detecting device according to claim **11**, wherein the image detecting device comprises a radiation solid-state detecting device for storing the radiation having passed through the subject as electric charge information, and reading the stored electric charge information as the radiation image information.

13. An image detecting device according to claim **12**, wherein the radiation solid-state detecting device comprises a light readout type detector for reading the stored electric charge information as the radiation image information in response to reading light being applied thereto.

14. An image capturing system comprising:

an image detecting device according to claim **1**; and

a controller for controlling the image detecting device.

15. An image capturing system according to claim **14**, further comprising:

a radiation generator for generating and applying radiation to a subject;

wherein the image detecting device records radiation having passed through the subject as a radiation image, and outputs the recorded radiation image to an outside as radiation image information; and

the controller controls the radiation generator and the image detecting device.

16. An image detecting device comprising:

an image detector for recording an image therein and outputting the recorded image as image information;

a temperature regulation controller for performing a temperature regulation control operation in order to adjust the image detector to a predetermined temperature;

an image information output detector for detecting the output of the image information from the image detector, and outputting the detected output as an image information output detection signal to the temperature regulation controller; and

a timer,

wherein the temperature regulation controller relaxes a temperature regulation control operation on the image detector based on the image information output detection signal input thereto, and stops relaxing the temperature regulation control operation on the image detector when the timer has measured a preset period of time after the temperature regulation control operation has been relaxed.

17. An image detecting device according to claim **16**, further comprising:

an image recording detector for detecting the recording of the image in the image detector, and outputting the detected recording as an image recording detection signal to the temperature regulation controller,

wherein the temperature regulation controller relaxes the temperature regulation control operation on the image detector based on the image recording detection signal or the image information output detection signal input thereto, and stops relaxing the temperature regulation control operation on the image detector when the timer has measured a preset period of time after the temperature regulation control operation has been relaxed.

18. An image detecting device according to claim **17**, wherein the timer measures a preset period of time from a time when the temperature regulation controller relaxes the temperature regulation control operation to a time when the output of the image information has been completed, or from the time when the temperature regulation controller relaxes the temperature regulation control operation to a time when recording of the image has been completed.

19. An image detecting device according to claim **17**, further comprising:

an area specifying unit for specifying a pixel for recording the image in the image detector, and outputting the specified pixel as a recording area for the image information to the temperature regulation controller, the image information output detector, and the image recording detector;

wherein the image information output detector detects the image information output from the pixel as the recording area;

the image recording detector detects the image recorded in a pixel that is not specified as the recording area in the image detector; and

the temperature regulation controller performs the temperature regulation control operation on the pixel of the recording area.

20. An image detecting device according to claim **16**, wherein the temperature regulation controller again relaxes the resumed temperature regulation control operation, when the timer has measured a preset period of time from a time when the temperature regulation controller has stopped relaxing the temperature regulation control operation.

21. An image detecting device according to claim **16**, wherein the temperature regulation controller outputs a recordable signal indicating that the image can be recorded in the image recorder to an outside, when the timer has measured a preset period of time from the time when the temperature regulation controller has stopped relaxing the temperature regulation control operation.

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